

# The role of knowledge users in public–private research programs: An evaluation challenge

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Many contemporary science systems are witnessing the rise of public–private research programs that aim to build capacity for research and innovation in strategic areas. These programs create a significant policy challenge: how to select—based on ex ante evaluations—a consortium that will carry out public–private research activities that will contribute to the overall policy goal of capacity-building in the science and innovation system? And how to make sure that knowledge users are involved in the research program in a meaningful way? The aim of this article is to explore the possibilities for ex ante evaluation of public–private research programs in a systematic comparison of 37 Dutch programs funded by the ‘Investment Grants for Knowledge Infrastructure’ (*Besluit Subsidies Investerings Kennisinfrastuur*) in 2004. Our research question is as follows: to what extent can involvement and commitment of knowledge users in the stage of drawing up the program proposal serve as a predictor of their later involvement and financial contribution? Using available archival data on the programs, we show that on average there is a close association between user involvement in the proposals of public–private research consortia and their eventual involvement during the implementation, but that there are substantial differences between plans and implementation in individual cases. Our analysis suggests that selecting consortia for funding based on their program proposals is possible and legitimate, but that strict rules are necessary to safeguard the financial contributions of knowledge users.

*Keywords:* consortium; public–private research; ppp; program evaluation; knowledge user; network.

## 1. Introduction

A number of large-scale complex societal problems feature prominently in current science and innovation policy plans, as they are assumed to demand major research efforts. The European Commission has identified several ‘Grand Challenges’, such as climate change and healthy aging, which will guide agenda-setting in its upcoming research funding framework, Horizon 2020 (European Commission 2011). Dealing with grand societal challenges is a challenge in itself. Public authorities, companies, and the public at large expect science to make a big contribution, but the question is how research on these challenges should be organized in order to generate social and

economic impacts. One common policy strategy is to launch large-scale public–private research programs.

Public–private research programs bring together a diverse range of actors,—both researchers and knowledge users,—around a certain theme with the intention of concentrating research activities and fostering relationships among participants. Such programs, which are governed by various organizational structures, such as Leading Technological Institutes in the Netherlands (van der Veen et al. 2005), Cooperative Research Centres in the USA (Turpin et al. 2011), and Networks of Centres of Excellence in Canada (Fisher et al. 2001), share the fundamental principle that the government delegates

responsibility for research programming to a consortium with a heterogeneous composition. The logic of delegating the research programming task to a varied network of researchers and knowledge users is that it saves transaction costs and provides a promising means of dealing with the lack of scientific expertise among policymakers (Braun 2003). However, consortia including both knowledge users and knowledge producers face the challenge of managing the involvement of the different participants, in terms of variety (range of actors) and depth (substantive and financial contributions). This creates a significant policy challenge: how to select,—using ex ante evaluations,—a consortium that will carry out public–private research activities that will contribute to the overall policy goal of capacity-building in the science and innovation system? In particular, how to make sure that knowledge users, as part of this heterogeneous consortium, can contribute to the research program in a meaningful way? Earlier studies have provided insights into the functioning of public–private research programs (Gray 2011; Kloet et al. 2013), and they have produced building blocks for monitoring and ex post evaluations (Klenk et al. 2010). The evaluation of public–private research programs is complicated owing to the multidimensional focus of these programs and the uncertain complex innovation processes involved (Salles-Filho et al. 2011), a lack of comparable data across countries (Lepori et al. 2007), and the limited possibility to measure long-term impacts (Rogers 2012). To date, little empirical analysis has been performed on the ex ante evaluation of such programs.

This article addresses the policy challenge of selecting public–private research programs, focusing specifically on assessing ex ante the role of knowledge users in the implementation and governance of these programs. The article studies 37 Dutch public–private research programs that were funded under a single government scheme, the ‘Investment Grants for Knowledge Infrastructure’ (*Besluit Subsidies Investeren Kennisinfrastuur* or BSIK) of 2004. All the programs funded were required to support collaborations between researchers and knowledge users, such as firms, governmental authorities, and nongovernmental organizations (NGOs). Second, they had to aim at large-scale economic and social challenges. Rather than delegating the selection and monitoring of the programs to a traditional research council, the government decided to set up a special high-level advisory committee to select and monitor the programs. The selection of programs for funding was based on general criteria such as scientific quality and societal relevance. The government or the Committee did not provide an organizational template for the programs and gave them ample room to develop their own governance structures. The ensuing variety, along with their user- and challenge-driven character, makes them an interesting object of study.

The aim of this article is to explore to what extent ex ante evaluation of public–private research programs

enables policymakers to select consortia that will carry out programs in which knowledge users are involved. The precise degree to which users should be involved is a normative question, the answer to which will depend on the theme and mission of the program. In our analysis, we do not intend to judge whether users are adequately involved, but rather explore to what extent policymakers can select consortia based on the degree of user involvement from the assumption that they will always demand a certain degree of involvement. To this end, we make a systematic comparison of the 37 ‘BSIK’ programs. Our research question is as follows: to what extent can involvement and commitment of knowledge users in the stage of the program proposal serve as a predictor of their later involvement and financial contribution? We will conclude our article with recommendations for science and innovation policymakers concerning the selection and governance of public–private research consortia.

## 2. Theoretical framework

### 2.1 Rise of public–private research programs

Many contemporary science systems are witnessing the rise of public–private research programs that aim to build capacity for research and innovation in strategic areas (Fisher et al. 2001; Gray 2011). The rise of public–private research programs is related to the increased complexity of the scientific enterprise and to the recognition that societal problems require collective efforts by public research organizations, governments, and industry (Gibbons et al. 1994). Pooling research projects and coordinating the efforts of individual researchers in a public–private research program are expected to enhance their common effectiveness in terms of producing research of the required scientific quality and societal impact (Hessels 2013).

Public–private research programs can be seen as a manifestation of the rise of ‘delegation to networks’ (Braun 2003). Network delegation in the science system implies that policymakers do intervene by providing funding for thematic programs, but assign a large proportion of the responsibility for content and internal decision making to a consortium of scientists and knowledge users. The state acts as a facilitator that retains the right to control but makes use of the existing relations, expertise, and self-interest of the research community, as well as creative and instrumental input of knowledge users (Braun 2003; Klerkx and Leeuwis 2008b).

As such, network delegation potentially has large benefits for the state: it decreases transaction costs related to control mechanisms, and it does not demand in-depth scientific expertise on the part of policymakers. However, the crucial step of selecting a consortium responsible for distributing funding and coordinating research projects based on ex ante evaluations is difficult. Given the inherent uncertainty of scientific research and the difficulties of

ex ante evaluation of the broader societal impacts of science, this challenge is always present in the process of allocating research funding (Merckx and Van den Besselaar 2008; Bozeman and Sarewitz 2011; Rogers 2012). The challenge is even more considerable when it comes to public-private research programs, as a result of three characteristics:

- (1) The substantial scale, with funding generally in the order of several million euros,
- (2) The heterogeneous composition of the consortia, which include research organizations, commercial firms, and/or governmental organizations (Spielman and von Grebmer 2006), and
- (3) The multidimensional focus of these programs and the uncertain complex innovation processes involved, using novel models of collaboration and user involvement (Salles-Filho et al. 2011).

## 2.2 The role of knowledge users in public-private research programs

The main challenge of consortium selection concerns the role of knowledge users in public-private research programs. These programs aim both for scientific excellence and for societal relevance. They involve knowledge users, such as governments, firms, or NGOs, in the agenda-setting and in the execution of the research, in order to include their knowledge needs in the research agenda and to stimulate cocreation of knowledge. For example, Canada's Networks of Centres of Excellence (Fisher et al. 2001) were inspired by the idea of Mode 2 knowledge production, which involves collaboration between various types of organizations, transgressing disciplinary boundaries, and introducing novel types of quality control (Gibbons et al. 1994; Hessels and van Lente 2008). In the same vein, the Cooperative Research Centres programs in Australia (Turpin et al. 2011) and the USA (Gray 2011) specifically aim to stimulate collaboration between universities and industry. The rationale behind user involvement is that academic research can have more impact on society or the economy if the activities of multiple organizations are combined, and if the responsibility for agenda-setting and knowledge transfer is shared by the research community and a set of societal stakeholders (Hessels 2013).

The science and innovation studies literature suggests that involving users in R&D can be beneficial. First, making use of the users' creative potential and experiential knowledge enhances the relevance and quality of scientific output (Caron-Flinterman et al. 2005; Von Hippel 2005). Second, users can facilitate the R&D process by making it more effective (Von Hippel 2005). Third, a more prominent role for knowledge users can lead to strong links between the activities of knowledge users and knowledge producers. Possible relationships include collaboration,

complementarity, similarity, relevance, and synchronicity. Eventually, such relationships enhance the societal or economic impact of the program in terms of legitimization of its output, utilization of the results, and interest in follow-up research initiatives (Roelofsen et al. 2011).

Involving knowledge users can be difficult, costly, and risky. In general, the more participating organizations there are, the higher the coordination costs (Cumings and Kiesler 2007). This is especially true of public-private research programs, in which different actors with their varying stakes and interests participate, and the agendas of academic researchers, commercial firms, and other knowledge users need to be aligned (Kloet et al. 2013).

Given their hybrid nature, public-private research programs by definition involve knowledge users in the funding, design, or implementation of the program. In some cases, users restrict their role to *funding* R&D. For example, charity funds in healthcare—representing patients, family members and donors—organize their calls for research proposals in a similar way as research councils. Knowledge users can also be prominent during the *agenda-setting* phase (Davenport et al. 2003). In this stage, they are often involved as one out of many experts and some cases even just as a token person. However, sometimes they take the lead in the agenda-setting phase in terms of organization and content (Elberse et al. 2012). Empirical evidence shows that programs may host users who are involved in all phases of the research cycle (Klerkx and Leeuwis 2008b). However, some studies have indicated that the prominent role of users in agenda-setting is not carried through during the *execution* of the research (Bozeman and Sarewitz 2005; Kloet et al. 2013; Wardenaar 2013). There are various conceptualizations of the degree of user involvement, ranging from variations on Arnstein's participation ladder to combinations of dimensions and attributes (Neef and Neubert 2011). One attribute of user involvement is the extent to which programs choose to include knowledge users in formal bodies, such as the board, steering committee, or program council (Joribert and Wesselink 2012). In these positions, users can give feedback on the progress of the program as a whole or the progress of individual projects, which enables them to influence the direction of the program and to shape it in relation to their own activities and knowledge needs. Such a role can lead to 'productive interactions', fruitful exchanges between researchers and stakeholders in which knowledge is produced that is valued as both scientifically robust and socially relevant (Spaapen and Van Drooge 2011). However, this type of participation does not imply an active contribution as operational partners in research projects. In many cases, firms participate in research projects to be up-to-date on current scientific directions and to scout for skilled and talented researchers, without aspiring to play a role as a coproducer of knowledge (Van Gils et al. 2009).

2.3 Research model

In this study, we will analyze the implementation of a set of public–private research programs in relation to a number of characteristics of these programs in the design phase (see Fig. 1). Given the above considerations, we will pay particular attention to the role of knowledge users. The distinction between the design phase on the left of the research model and the research phase on the right directly reflects the relationship between program proposals and ‘later involvement and financial contribution’, which is the focus of our research question. The implementation of the program will be analyzed in terms of three variables: the involvement of knowledge users in decision making (D), their financial contribution (E), and the types of output and appreciation of the program (F). In order to investigate the correspondence between program design and program implementation, we shall explore the extent to which each variable is associated with a matching characteristic of the consortium in the program design phase (variables A, B, and C). In addition, a number of other relationships will be explored, based on more tentative hypotheses (indicated with dotted arrows in the model). In our analysis, the term ‘program’ refers to a collection of research activities with a certain degree of substantive coherence and organizational delineation. With ‘consortium’, we refer to a set of partners committed to a common research program.

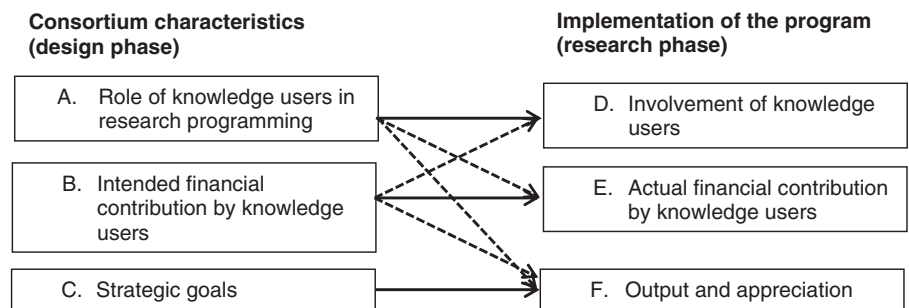
**2.3.1 The involvement of knowledge users.** First, we analyze the degree to which knowledge users are involved during the research phase (D) in relation to their role in the design phase (A). Interactions with knowledge users during actual research activities tend to increase researchers’ awareness of the potential practical applications of their work (Hessels 2013). This type of contact can lead to adjustments in the project content, which enhances the project’s relevance to industry or other users. Knowledge user–producer interactions in the implementation phase can be organized in various ways: by setting up user committees, by conducting part of the

work in-house at a firm or other user organization, or through other in-kind contributions. In this article, we analyze the influence of knowledge users on the research agenda.

User involvement during the design phase (A) can create a common focus and relevance in the activities of both parties (Hemlin and Rasmussen 2006). It allows stakeholders to articulate their knowledge needs and to shape the content and organization of the research program. Knowledge users can make this contribution either by being directly involved in the writing process or by participating in brainstorm sessions or other forms of consultation.

**2.3.2 Financial contribution from knowledge users.** Second, we analyze the *actual* financial contribution provided by knowledge users (E) in relation to their intended contribution during the program design phase (B). Although knowledge is often regarded as a ‘public good’ (Arrow 1962; Stiglitz 1986), there are plenty of sectors where private parties have an interest in investing in collective research, as this is cheaper than conducting research in-house. In agriculture, farmer levy funding of R&D is an institutionalized way of end-user demand steering of R&D in which farmers form collectives that become clients of R&D providers (Klerkx and Leeuwis 2008a). Obviously, investment in R&D by users pertains more to applied research, but in many research areas, such as chemistry (de Wit et al. 2007), firms and other knowledge users also fund precompetitive strategic research.

Some policy instruments provide users with the opportunity to influence the content of research programs without making a financial contribution, but public policies for research in strategic areas increasingly aim at inducing industry or other users to provide substantial contributions to the research budget. This obviously enhances the available research capacity and, furthermore, makes users more committed to the activities performed (Hegger et al. 2012). Adopting user funding as a determinant for R&D programming has the upside that users have



**Figure 1.** Research model. The main arrows indicate the main relationships under study between a program variable in the research phase and a corresponding variable in the design phase. The dotted arrows indicate a number of other relationships which will be explored, based on more tentative hypotheses.

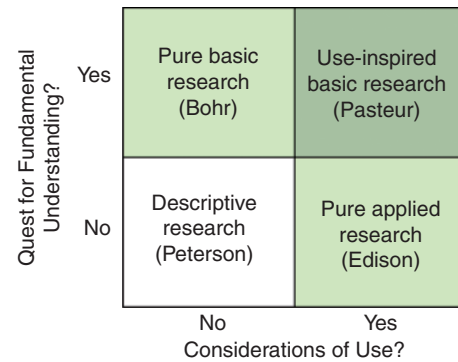


a ‘practical perspective on costs and benefits which scientists themselves may lack’ (Stewart 1995). This might be an effective way of applying R&D funding in strategic research, at any rate (Johnson et al. 2003). The downside is that users may have difficulty valuing the benefits of basic research.

In order to make users interested in funding R&D, a large-scale public-private program must offer a perspective on significant revenues. In health research, for example, charity funds and pharmaceutical companies participate in precompetitive public-private programs because their research objectives require investments that a single company could not carry and their outcomes are difficult to appropriate (Reich 2000). In general, users face a trade-off between benefiting from public subsidies by investing in collective research, and exclusive access to knowledge and intellectual property by outsourcing research individually.

**2.3.3 Output and strategic goals.** Third, we explore four types of output, reflecting the scientific achievements and the practical output of the programs (F). Although the output of a research program does not directly reflect the role of knowledge users, the balance across various types of output does indicate a relative orientation toward the development of products for scientific audiences versus products for nonacademic knowledge users and in this way can be regarded of a manifestation of user involvement. Straightforward and commonly accepted indicators for the analysis of scientific output are counts of scientific publications and PhD degrees awarded. The practical output of scientific research is difficult to measure, given the wide variety of practical products that can be generated (de Jong et al. 2011; Hessels et al. 2011). Owing to the limited data available, the analysis in this article will focus on practical output in terms of the numbers of patent applications and spin-off firms created. In addition, we analyze the qualitative assessment of a responsible evaluation committee as an indication of the overall quality.

The output of the programs will be analyzed in relation to the strategic goals of the programs (C). A predominantly scientific program will demand different coordination processes than a predominantly practical program. To classify the programs in our data set, we chose to go beyond the traditional dichotomy of basic versus applied research, and use Stokes’ Quadrant (Stokes 1997). The two dimensions constituting this quadrant model are the relative commitment to considerations of use and the relative commitment to the quest for fundamental understanding (see Fig. 2). Stokes has named three quadrants after exemplary researchers: pure basic research (Niels Bohr), use-inspired basic research (Louis Pasteur), and pure applied research (Thomas Edison). In the original presentation, the fourth box remained unnamed, but Stokes did refer to ornithologist Roy Tory Peterson as an example, since research in this area is mainly oriented



**Figure 2.** Stokes’ quadrant model (Stokes 1997), with a name added for the fourth quadrant.

at description and classification (Stokes 1997: p. 75). In this article, we will therefore refer to it as the ‘Peterson’ quadrant.

## 3. Methods

### 3.1 General approach

We opted for a comparative approach in exploring the possibilities for ex ante evaluation of public-private research programs. The set of programs funded by the BSIK is an interesting area for our endeavor. The BSIK policy aimed to increase the societal relevance of the Dutch science system. To meet this objective, the government made 802 million euros available from the national gas reserve fund for a temporary subsidy for public-private research programs. Consortia of research organizations, firms, and/or governmental organizations were invited to submit program proposals, which might qualify for 50% BSIK funding; the other half had to be ‘matched’ by consortium partners. A special high-level advisory committee (the so-called ‘Commissie van Wijzen’) was installed to advise on the awarding of funding to individual programs and to report to the government on the progress of the BSIK funding program as a whole through annual reviews. The committee assessed the proposals on the quality of the proposed activities in terms of scientific excellence and potential for societal and economic results. A third main criterion for selection was the structural involvement of knowledge users, such as companies and NGOs, that would contribute to the creation of knowledge networks.

The Committee received advice from the Royal Netherlands Academy of Arts and Sciences (KNAW) and from the CPB Netherlands Bureau for Economic Policy Analysis. NL Agency, the agency of the ministry of Economic Affairs, was responsible for the administrative follow-up and helped the Committee monitor the programs. A total of 37 public-private research programs covering five different themes were awarded grants. All the programs operated within the same policy framework, but

had no fixed organizational template. Given their relative autonomy, each program had to choose its own governance structure, which means that the set of programs can serve as a fruitful domain for comparative analysis.

A particularly interesting feature of the BSIK framework is its temporary nature. In the Dutch science system, the coordination of research activities has traditionally been the preserve of permanent organizations (Hessels and Deuten 2013), particularly the Netherlands Organization for Applied Scientific Research (TNO), KNAW, and the Research Council for Pure Scientific Research (ZWO). Since the 1980s, however, when new strategic research areas began to emerge that called for collaboration between public research organizations and industry, research has increasingly been organized in the form of public-private partnerships. These new intermediaries often had a temporary status, lasting only for the duration of a limited grant program. The 37 BSIK programs under study in this article are examples of such intermediary organizations.

This article is based on archival research at NL Agency, the agency of the ministry of Economic Affairs responsible for monitoring the BSIK programs. NL Agency gave us unrestricted access to the relevant archives of the BSIK programs, as well as assistance where necessary. Our main data sources are listed in Table 1. The various sources span the entire lifetime of the programs, from the design phase to the implementation and wrap-up.

Data collection was structured by a long list of 176 indicators, producing a database with systematic information on all 37 programs. The set of indicators was composed in order to capture as much available information as possible about the governance of the programs, their aims, budgets, and output. Data collection was carried out by a team of three research assistants led by one of the authors. Eventually, a selection of relevant indicators was used for our analyses. Some of the indicators are straightforward counts, such as the number of PhD degrees awarded. Other indicators, such as the relative influence of a user committee, required interpretation and judgment by the data collector. After analyzing two programs as pilot cases, the data collectors discussed their coding approaches

with each other and with the authors. Random cross-checks were also performed to monitor interpretations between data collectors. The authors conducted interviews with the unit director responsible for monitoring the programs at NL Agency and with three members of the high-level advisory committee to validate the data and help interpret the findings. Moreover, the authors were involved in in-depth qualitative studies on several specific programs, such as the Ecogenomics Consortium, Next-Generation Infrastructures, and Climate changes Spatial Planning (Kloet et al. 2013; Roelofsen et al. 2011; Wardenaar et al. 2014).

We operationalized the distinction between design and the research phase as the moment of program selection, based on the program proposal and related documents as listed in Table 1. Given the lack of instructions from the government, the division of activities over these two phases differed across programs. For example, some programs had designed individual research programs in the design phase and specified them in their program proposals, while other proposals only sketched activities in general terms. Although the activities between the two phases may show a certain degree of overlap, we do believe that it is possible and necessary to make such a distinction in order to answer our research question.

Three limitations of our data set deserve a mention. First, although both NL Agency and the high-level advisory committee checked all documentation, thus limiting the likelihood of factual errors, it should be underlined that most data were self-reported by the program consortia. This might result in higher output numbers, since researchers can typically attribute the same publication to multiple funding sources. Second, although the program evaluation reports are standardized thanks to NL Agency's monitoring approach, they vary significantly in terms of their content and structure. In principle, our database only covers information reported in the documents available, so some activities or achievements may have been missed. In general, however, program managers tended to report manifestations of user involvement relatively well, as they were appreciated by the high-level advisory committee. If activities were not reported, it is therefore safe to assume that they did not occur. Third, we were unable to fill in certain variables for some of the programs because of the quality of the available documentation. For example, three programs had only just been completed at the time of the study (TREND, KvR, and ESI) and one had not actually been completed (NGInfra), which meant that they could not supply complete data about finances and output. Overall, these limitations suggest that data about individual programs can deviate, which restricts the possibilities to assess the performance of individual programs. However, there is no reason to assume that there are systematic errors which constrain the possibility to analyze general trends across different programs.

**Table 1.** Main data sources

Phase of the program	Data sources (for each program)
Design phase	Program proposal Business plan/project plan Baseline assessment
Research phase	Mid-term review Annual reports Final report (by program management) Assessment by high-level advisory committee

**Table 2.** Definition of the scores for the role of users in research programming

Role of knowledge users	N	Numerical score
No contribution to the program proposal	5	0
Limited consultation of users	10	1
Users signed letters of support indicating their interest in the program	2	2
Users were part of the writing committee	16	3
Other/unknown	4	–
Total	37	

### 3.2 Operationalization of the main variables

**3.2.1 Role of knowledge users in research programming.** The role of knowledge users in research programming was characterized on a numerical scale from 0 to 3, as presented in Table 2. The scale is defined in terms of the contribution knowledge users made to the program proposal. In 16 cases, users acted as coauthors of the text. A somewhat weaker form was chosen by two programs that approached users with their draft proposals, inviting them to sign letters of support to indicate their interest. The minimal form of consultation was to inquire about knowledge users' interests, without asking for any commitment.

**3.2.2 Intended financial contribution by knowledge users.** The intended financial user contribution was calculated using figures from the program proposals or business plans. In our operationalization, we defined knowledge users as all organizations that did not qualify as knowledge producers, such as research institutions. Research institutions are all public and semipublic organizations whose primary mission is to produce knowledge: universities, basic research institutes,<sup>1</sup> and applied research institutes.<sup>2</sup> Knowledge users are all private organizations and all public and semipublic organizations whose primary mission is not the production of knowledge. These include firms, governmental organizations, and NGOs. To control for different program sizes in our analysis, we used the ratio between the intended financial contribution of knowledge users and the intended financial contribution of research institutions. Given the quality of the available documentation, this figure could only be calculated for 23 programs.

**3.2.3 Strategic goals.** The BSIK were designed to strengthen the Dutch knowledge system and stimulate both scientific excellence and societal impact. Although all BSIK programs were selected on the basis of high

**Table 3.** Classification of the programs in terms of Stokes' quadrants

	Emphasis on practical goals	
	Very weak, weak, or neutral	Strong or very strong
Emphasis on scientific goals		
Strong or very strong	Bohr (N = 16)	Pasteur (N = 12)
Very weak, weak, or neutral	Peterson (N = 2)	Edison (N = 7)

scores for scientific excellence as well as economic relevance, the relative emphasis on scientific and practical goals varied significantly between individual programs. To characterize the programs in terms of Stokes' quadrants, the relative emphasis on scientific goals and the relative emphasis on practical goals in the program proposal or baseline assessment were rated by our research team on a five-point scale ranging from 'very weak' to 'very strong' for both scientific and practical (i.e. economic or societal) goals (see Table 3). These two goals were scored independently, and our assessment was based on the different targets set by the consortium and the ambitions defined. Emphasis on scientific goals scored as 'high' when the proposal included multiple and specific references toward scientific goals, such as above average targets for scientific publications and PhD degree, the organization of and participation in scientific congresses, citation impact, and when the mission and/or strategy sections frequently mentioned terms such as 'scientific excellence' without a direct connection to application. Emphasis on practical goals scored as 'high' when the proposal made multiple and specific references to economic goals, such as ambitious targets for patents, spin-offs, technology user interaction working sessions or when the mission and strategy sections referred explicitly to valorization or practical applications.

Obviously, it is based on self-presentation in the different programs, which may include a strategic component, and this assessment should therefore be interpreted as an indicator of the strategic positioning of the programs, rather than an objective indicator of the orientation of the programs toward fundamental research or practical application. Any results flowing from this classification should therefore be interpreted with the caveat that this classification is only a rough proxy for actual strategic focus.

**3.2.4 Involvement of knowledge users during the research phase.** The influence of knowledge users during the research phase was analyzed on three levels:

- Influence on decisions regarding individual projects (project level)



**Table 4.** Definition of the scores for user influence

Description	Definition	Numerical score
No influence	Knowledge users have no influence at this particular level	0
Indirect influence	Influence by way of an advisory body that interacts with the program at this particular level	1
Direct influence	Influence by a right to vote in the decision-making body at the level in question. Knowledge users have a structural influence over a significant number of projects or activities.	2
Direct and indirect influence	Influence through both an advisory and a decision-making body	3

- Influence on decisions regarding a larger set of projects organized into a theme or work package (subprogram level)
- Influence on decisions regarding the program as a whole (program level)

In addition, we calculated the average score at these various levels for each program.

We measured the involvement of knowledge users in terms of their estimated *influence* on the actual research agenda. Based on the available documentation we scored the influence on a numerical scale, as explained in Table 4.

**3.2.5 Actual financial contribution from knowledge users.** This value was calculated on the basis of figures reported in the final accounts of the programs. As with the *intended* financial contribution, we used a ratio between the contribution of knowledge users and knowledge producers.

**3.2.6 Output and appreciation.** We analyzed the scientific output of each program in terms of two indicators as measured in the final reports. First, the number of academic peer-reviewed papers (disregarding book chapters and conference contributions). Second, the number of PhD degrees awarded to researchers funded by the programs.

As indicators for the practical outputs of the programs we analyzed the number of patent applications and the number of new spin-off firms to have emerged from the research conducted as part of the program. These variables reflect only a limited share of all possible practical outputs, mainly emphasizing economic impact and disregarding media contributions and policy advice, for example. However, these variables are the only types of practical outputs that have been systematically documented by all programs under study.

Finally, we analyzed the evaluation of the high-level advisory committee in their final report to the government. In this report the committee graded each program as ‘highly successful’, ‘successful’, ‘satisfactory’, or ‘partly successful’, which we translated to a four-point ranking to enable statistical analysis.

## 4. Results

### 4.1 Descriptive overview of the programs

Table 5 provides an overview of the 37 programs that received BSIK funding, their budgets, the role of knowledge users, the ratio between the financial contributions of users and producers, and a characterization of their strategic goals. The budgets of the programs range from 14 to 179 million euros with an average of 45 million euros. As indicated above, the most popular models for user involvement in the design phase are ‘limited consultation’ (N = 10) and ‘participation in the writing committee’ (N = 16). The ratio between the financial contributions of knowledge users and knowledge producers varies from 0.00 (BRICKS, B-Basic) to 2.00 (LOFAR) in the intended budget, and 1.30 (also LOFAR) in the actual budget. The average ratio is about 0.4. One remarkable change from intended to realized input was the shift in the B-Basic program, from 0 to 1.14.

### 4.2 Involvement of knowledge users

The first relationship explored is that between the involvement (influence) of knowledge users at various program levels (A) and the role of knowledge users during the design phase (D). Table 6 shows that there is a significant weak to medium correlation at all program levels. The relationship is strongest at the subprogram level and fairly weak at the program level.

Given the ordinal character of the ‘knowledge user influence’ indicator and the small sample, we simplified our four-point scale indicator to a dichotomous measure indicating participation versus nonparticipation in the writing committee. Table 7 gives the median scores of these groups for the role of knowledge users during the research phase. The scores are in line with our earlier results. A Mann–Whitney test roughly confirms these results because a significant effect on subprogram level influence and average influence was found. This result does not hold for the project and program level.

We also investigated an additional hypothesis that was tentatively shown in our formal research model: the relationship between financial contribution and user involvement. There are no significant correlations with the relative



**Table 5.** Overview of the programs and a number of key characteristics (if known)

Program name (abbreviated)	Topic	Actual budget (x million euros)	Role of knowledge users in research programming <sup>a</sup>	Strategic goals (quadrant)	Intended funding ratio users : producers	Realized funding ratio users : producers
BRICKS	Informatics	27	0	Bohr	0.00	0.00
Gigaport NG	Data networks	86	1	Edison	0.61	1.26
SRG	Spatial planning	66	–	Bohr	0.37	–
KSI	System innovations	22	0	Bohr	–	–
Nanoned	Nanotechnology	179	3	Bohr	0.08	0.07
MultiM	Multimedia	35	3	Pasteur	0.29	0.43
SCDD	Stem cells	20	1	Bohr	0.00	0.23
ICIS	Intelligent systems	30	1	Pasteur	0.94	0.99
TREND	Posttraumatic dystrophy	22	1	Bohr	0.06	0.10
Nbsik	Mouse phenomics	28	3	Edison	–	–
NPC	Proteomics	68	1	Bohr	–	–
NBIC	Bio-informatics	–	–	Bohr	–	–
Biomade	Molecular nanotechnology	15	0	Edison	0.12	0.11
LOFAR	Multiple sensor array	107	0	Edison	2.00	1.30
Cyttron	Bio-imaging	21	–	Bohr	0.21	0.16
Delft Cluster	Urban infrastructures	51	1	Pasteur	0.20	0.74
NG	Nutrigenomics	21	3	Bohr	–	–
ESI	Embedded systems	49	3	Pasteur	0.07	0.00
KvR	Climate and spatial planning	84	1	Bohr	–	–
Virgo Consortium	Respiratory virus infections	21	3	Pasteur	0.29	0.20
VL-e	e-science	43	3	Pasteur	0.48	0.11
CDC	Celiac disease	18	3	Bohr	0.01	0.00
LmW	Water management	56	1	Peterson	–	–
Microned	Microsystems	54	3	Pasteur	0.30	0.20
Molecular Imaging	Molecular imaging	24	3	Bohr	0.13	0.07
B-Basic	Bio-based materials	54	1	Bohr	0.00	1.14
DPTE	Tissue Engineering	55	1	Pasteur	–	–
CATO	Carbon capture and storage	27	3	Pasteur	0.25	0.30
Eco-genomics	Ecogenomics	22	0	Bohr	0.29	0.14
Smart Surroundings	Ambient systems	14	–	Pasteur	0.86	0.55
Freeband	Telecommunication	60	3	Pasteur	1.21	0.45
NGInfra	Infrastructural systems	19	3	Pasteur	–	–
PSI Bouw	Construction	–	3	Edison	–	–
RGI	Geo-informatics	46	3	Bohr	–	–
Transumo	Mobility	60	1	Edison	–	–
Transforum	Sustainable agriculture	59	3	Edison	0.86	1.09
We@sea	Off-shore wind power	21	1	Peterson	–	–
Average (non-weighted)		45	N.A.	N.A.	0.40	0.42

<sup>a</sup>0: no contribution; 1: limited consultation; 2: letters of support; 3: part of writing committee; –: unknown/other.

intended financial contribution of knowledge users (N = 23). This indicates that the degree of involvement by knowledge users during the research is strongly associated with their involvement during the programming phase, but not with their intended financial contribution.

### 4.3 Actual financial contribution

In many programs, the actual financial contribution of knowledge users deviated substantially from the intended contribution (see Fig. 3). The ratio remained equal (that

is, 0) in one case, increased in nine cases and decreased in 13 cases. On average, the ratio increased slightly from 0.40 to 0.42, but this effect was due to one case. Without B-Basic, the average ratio decreases from 0.42 to 0.39. Apart from these dynamics, the ratio between the intended contributions of knowledge users and knowledge producers correlates with the ratio between their actual contributions (N = 23; Pearson correlation: 0.635;  $P < 0.001$ ). No significant correlation was found between the actual proportion of financial contribution and the influence of knowledge users at any of the three levels.

**Table 6.** Correlations in the influence of knowledge users at various levels and the role of users during the design phase

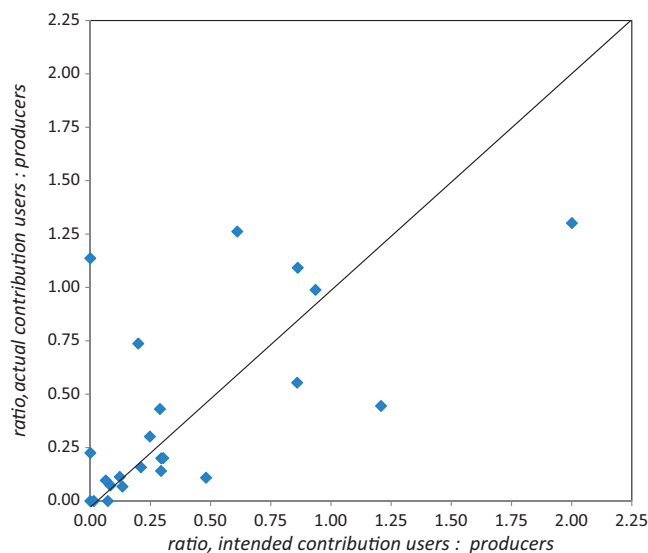
Influence of knowledge users on the research phase	Spearman correlation (with role of users during design phase)
Project level	0.406** (N = 33)
Subprogram level	0.609*** (N = 30)
Program level	0.337* (N = 32)
Average influence (in cases the influence on all levels was known)	0.589*** (N = 29)

\* $P < 0.1$ ; \*\* $P < 0.05$ ; \*\*\* $P < 0.01$ .

**Table 7.** Nonparametric comparison of influence of knowledge users when part of the writing committee versus not part of writing committee

Influence of knowledge users during the research phase:	Not in writing committee	Writing committee	Significant differences ('Writing committee' minus 'not in writing committee') <sup>a</sup>
Project level	2.0 (17)	2.0 (16)	
Subprogram level	0.0 (16)	1.5 (14)	+1.5**
Program level	1.0 (16)	2.0 (16)	
Average influence	0.67 (15)	2.0 (14)	+1.3*

<sup>a</sup>Mann–Whitney test, not corrected for ties.  
\*Significant on 5% level; \*\*Significant on 1% level.



**Figure 3.** Actual financial contribution by knowledge users versus their intended contribution (N = 23). Both are depicted as the ratio between the contributions of knowledge users and knowledge producers.

#### 4.4 Output and evaluation score

None of the relative output indicators correlates with the share of intended financial contributions from knowledge users or the role of users in the programming.

A comparison of the four quadrants indicates that the relative emphasis on various goals at the outset relates to the output of the programs to some extent (see Table 8). Programs that place strong emphasis on scientific goals do indeed produce relatively more publications and PhD degrees than those with a weaker emphasis on these goals. The highest number of patents and spin-off firms are created in Pasteur’s quadrant programs, which emphasize both scientific and practical goals in their proposals. The six programs in Edison’s quadrant (low emphasis on scientific goals and high emphasis on practical goals) produce relatively little on average in most output categories. This could be explained by the fact that our output indicators are restricted to scientific output and commercialization, whereas other practical outputs such as policy innovations or public debate were not documented sufficiently to be captured in this study.

The final evaluation of program performance by the high-level advisory committee is also highest for programs that have a strong emphasis on scientific goals. The programs in Edison’s quadrant score slightly lower on average. There are insufficient programs in Peterson’s quadrant to make a systematic comparison, but they also score relatively low.

#### 5. Conclusions and discussion

National governments face a policy challenge in selecting consortia that will carry out adequate public–private research programs. Given the substantial size, heterogeneous composition, and complex tasks of the desired programs, it is difficult for governments to select consortia that contribute optimally to the overall policy goal of capacity-building in the science and innovation system. This article contributes to the understanding of coordination in science by a systematic comparison of 37 public–private research programs. We analyzed the involvement of knowledge users during the implementation of the programs in relation to a number of characteristics of the research consortia in the design phase.

The main finding of this article is that, in general, the plans of research consortia give a reasonable indication of the involvement of knowledge users during the implementation of the program and their financial contribution. In agreement with the case study by Kloet *et al.* (2013), we found that the implementation of many individual programs deviated significantly from the intentions expressed in program proposals. However, we found significant correlations between the degree of user involvement in the design phase and their involvement in decision making at various program levels while the

**Table 8.** The average output (unweighted) and evaluation scores compared across the four quadrants

	N	Average number of publications per million euros	Average number of PhD degrees per million euros	Average number of patents per million euros	Average number of spinoff firms per million euros	Average evaluation score
Overall mean (standard deviation)	35	7.7 (7.4)	0.68 (0.44)	0.24 (0.55)	0.082 (0.11)	2.8 (N = 36)
Peterson	2	2.0	0.38	0	0.05	1.5 (N = 2)
Bohr	15	9.1	0.75	0.13	0.06	3.0 (N = 16)
Pasteur	12	9.3	0.86	0.41	0.11	2.9 (N = 11)
Edison	6	2.9	0.20	0.24	0.096	2.4 (N = 7)

research was being carried out. The eventual financial contribution of knowledge users also correlates with their intended contribution as promised in the consortium proposals. This suggests that user involvement in the early stages of program design tends to give an indication of the way in which knowledge users participate in coordinating programs, shaping the content and governance of large-scale research programs. Building on earlier in-depth studies (Klerkx and Leeuwis 2008b; Roelofsen et al. 2011), further research might provide a deeper understanding of this process through qualitative analyses of these kinds of programs, based on interviews with program managers, researchers, and knowledge users.

Second, it appears that within the set of programs studied, those consortia more oriented toward scientific goals performed better in several respects. As can be expected, they produced on average more scientific publications and more PhD degrees. But they also created more patents and received a higher score from evaluation committees. A possible explanation is that scientifically oriented programs benefit from existing networks of scientific researchers, whereas programs with lower scientific ambitions depend more strongly on new relationships between public researchers and knowledge users to achieve their goals (Bercovitz and Feldman 2011). Building such relationships may require more time than the 6–8 years that most programs lasted (Rogers 2012). Literature about inter- and transdisciplinary research generally agrees that it takes time to establish collaborations across disciplinary and organizational boundaries, owing to differences in norms and incentive structures (Hegger et al. 2012; McNie 2012). It seems that in the cases of programs with lower scientific ambitions, the involvement and commitment of knowledge users in the stage of drawing up the program proposal, e.g. in the form of including users in program agenda-setting, do not increase the output as measured in terms of publications, PhD degrees, patents, or spin-off firms. Note that such programs might well have generated other types of output, such as policy advice or public debate, which have not been systematically documented here. Besides ‘tangible’ outputs, programs might lead to ‘intangible’

outputs such as the creation of a context conducive to combining research results with non-research-related innovation activities, resulting in, for example, building product prototypes (Salles-Filho et al. 2011). This especially applies to programs that are rather more focused on innovation and cocreation of novel products than on knowledge production. A current challenge for research evaluation is to develop indicators that make these intangible outputs visible (Spaapen and Van Drooge 2011). More advanced indicators could help to qualify the relatively low output of Edison programs.

Third, our analyses suggest that there is a substantial difference between the involvement of knowledge users in financial terms and their involvement in terms of influence on the content. The influence of knowledge users during the research is associated with their role in the design phase, but it does not correlate with their relative financial contribution. Their eventual financial contribution is associated with their intended financial contribution, but it shows no correlation with their *role* in the design phase. Apparently, in some programs, users prefer to delegate research tasks to the research community: they are willing to make significant financial contributions while leaving decision making to the research community. This finding is in line with an earlier finding that knowledge users often participate in public-private research programs for other reasons than knowledge acquisition, such as scouting for talented human resources or technology assessment (Van Gils et al. 2009). Another possible explanation might be a lack of cognitive resources. Although a few studies reveal programs supporting specific capacity building to develop the ability to articulate knowledge demand (Jacob 2005; Klerkx and Leeuwis 2008a), user organizations may not possess the absorptive capacity to assimilate and/or discuss the knowledge produced or the competence to articulate their knowledge demands (Boon et al. 2011). Conversely, in some programs in this scheme, users were granted an influential position without providing a financial contribution. Overall, it seems that during the design of research programs negotiations about content and funding are two parallel tracks without strong linkages.

### 5.1 Policy implications

To conclude, let us reflect on the policy implications of our findings. Note that this article does not intend to express normative judgments about the relative success of the individual programs under study, as a robust evaluation would require additional analysis of both their scientific output and broader impacts. Rather, we intend to formulate recommendations for public policy based on the aggregated analysis of 37 public–private programs funded by a common scheme.

In general, our findings that the consortium proposals give a reasonable indication of the role of knowledge users, their financial contribution and the output of the programs suggest that it is possible and legitimate to make a selection of consortia for funding based on their proposals. Governments aiming to stimulate public–private research programs with intensive user involvement should select them based on the degree of user involvement in the program design and the intended financial contribution.

The many discrepancies between program proposals and implementation of individual programs confirm the general image of science as an unpredictable activity. Apparently, research activities are not only difficult to foresee in terms of their content, but also in terms of their governance and coordination structures. Since the scheme under study did not demand a predefined governance structure, the ensuing set of programs illustrates this unpredictability by being a remarkably heterogeneous set in terms of their goals, processes, and output. The role of knowledge users during the research varied strongly between programs, and in many cases, deviated from the role they played in the program design phase.

The programs also differed strongly in terms of their productivity, i.e. in their scientific and practical output. Although we did find significant correlations, the implementation of many individual programs deviated strongly from the design in the program proposal. These deviations may be due to strategic rhetoric in the consortium proposals intended to maximize funding chances, rather than providing an honest representation of plans and ambitions. However, the deviations may also simply reflect the inherently limited possibilities of planning complex research programs and predicting their outcomes. Anyhow, if substantial public investments (hundreds of million euros) are being made, more consistency between consortium proposals and program implementation seems desirable. This is, for example, expressed in the financial contributions by users. As has been indicated by the high-level advisory committee, the total industrial contribution to the programs is disappointing from a societal perspective (Commissie van Wijzen Kennis en Innovatie 2011). We recommend policymakers to use stricter rules than the regulations governing the Dutch BSIK framework to safeguard the financial contributions of industry and other user organizations.

Overall, our analysis confirms that the selection of public–private programs is a considerable challenge, especially in the case of a temporary funding instrument such as BSIK. Owing to its temporary nature, the BSIK policy did not provide a straightforward opportunity for a systematic learning process. Policy learning can strongly enhance innovation policies (Borras 2011). A permanent public policy for supporting public–private programs would facilitate a policy learning process of both the government as a program selector [‘government learning’ in the typology of (Bennett and Howlett 1992)] and of the consortia in producing their proposals and governing their activities (‘social learning’). Owing to the temporary nature of BSIK, neither of these learning processes could reach their full potential. First, the temporary advisory committee responsible for the program selection could not systematically benefit from earlier experience. Second, some of the programs under study could benefit from personal experience of program directors or program officers in similar public–private research programs, but many needed to ‘reinvent the wheel’. The wide variety of observed coordination approaches illustrates this. A systematic learning process would also require complete documentation, which was lacking in many cases. Given these considerations, we recommend governments to strongly strive for continuity in their policies for supporting public–private research, in order to facilitate policy learning.

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### Notes

1. Research institutes that are governed by NWO or the KNAW.
2. The Netherlands Organization for Applied Scientific Research (TNO) and the four ‘major technological institutes’ Marin, ECN, Deltares, and NLR.

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